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ABSTRACT

The purpose of this system is to teach high school students basic principles and processes of electric arc welding. Safety features are stressed. The student generally follows a three-step sequence: 1) he views one of the eight demonstration films; 2) he works through a corresponding unit of programed material; and 3) he practices the aspects of welding depicted in the film and programed text. Student self-evaluation is accomplished by means of end-of-unit reviews and performance checklists. Included here are directions for administering the test, the performance checklist, and instructions for rating student welds. Achievement data available from laboratory and field tests indicate that students are able to perform a variety of welding tasks after completing this system. Additionally, 83 percent of the safety features were achieved by at least 85 percent of the students. Attitudes of students and teachers towards the system were found to be positive. (The programed material is not included in this booklet.) (JK)

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A Self-Instructional System in Welding

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PREFACE

This document is the third in a series of technical reports to be issued by the Research and Evaluation Division of the Northwest Regional Educational Laboratory. The reports will be published to provide people outside the Laboratory, e.g., funding personnel, potential users and professional colleagues, with data to indicate the quality of Laboratory products.

This report is a brief description, analysis and history of a self-instructional system in electric arc welding. Laboratory work on the system has been done in the program to improve instruction in small schools.

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DESCRIPTION OF THE SYSTEM

Instructional Objectives

The purpose of the self-instructional system in welding is to teach high school students basic principles and processes of electric arc welding. In attaining the objectives of the system, the student learns:

Equipment and Safety

To wear appropriate clothing while welding

To adjust the welding machine for 125 amperes

To identify the bare end of the welding electrode

To place the bare end of the welding electrode in the groove of the jaws of the electrode holder

To clamp metal securely before starting to weld

Welding and Safety

To position properly the electrode and electrode holder before turning the welding machine ON

To turn the welding machine ON without arc flash occurring

To preposition the electrode close to base metal prior to striking arc

To shelter eyes before striking an arc

To strike an arc with a fluid, smooth scratching movement of electrode

To keep work area safe by properly disposing of electrodes

To turn machine OFF at completion of practice sessions

To use a chipping hammer and wire brush when removing the slag from the weld beads and cleaning the metal surface

To identify correct and incorrect beads

To perform five welds, i.e., flat stringer beads, fillet welds, fillet welds with weave bead, weave beads and horizontal fillet with multiple pass, which show good penetration, uniformity and adequate size and do not exhibit undercutting, excessive spatter or excessive piling up of metal or overlap

To perform a sixth welding operation, restarting beads, which shows sufficient metal deposit and does not exhibit excessive metal deposit

Instructional Equipment and Materials

The self-instructional system in welding utilizes the following equipment and materials:

Fairchild Mark IV projector

Eight demonstration loop films:*

Equipment and Safety

Striking an Arc

Running Beads

Fillet Weld

Welding Essentials

Weave Beads

Fillet Weld (Weave Bead)

Horizontal Fillet (Multiple Pass)

*Major parts of the films were contributed by Air Reduction Company, New York, New York.

Two programed textbooks:

Sergeant, H. and D. Nish. Electric Arc Welding--Instruction Book I. Pullman: Department of Education, Washington State University, 1968.

Sergeant, H. and D. Nish. Electric Arc Welding--Unit 2. Pullman: Department of Education, Washington State University, 1968.

Two answer booklets which contain:

Answer sheets for programed instructional material

One review test for each of the eight instructional units

One checklist for each of the eight practice sessions

One manager's guide:

Vocational Educational Research Project. Electric Arc Welding Instructor's Guide (Revised Edition), Pullman: Department of Education, Washington State University, 1969.

Welding hardware:

Lincoln A. C. "Idealarc" 250 Arc Welder

Welding leads

Electrode holder

Ground clamp

Chipping hammer

Wire brush

Five gallon water bucket

Pliers

Supply of prepositioned steel for fillet weld

Example fillet welds (mounted)

Metal clamp

Welding head shield with safety flip lid

Welding gloves

Welding apron

Welding jacket

Welding practice table

Supply of welding electrodes 1/8" E 6013

Practice steel (3/16" thick, 1-1/2" wide and 5" long)

Stand to position steel for fillet weld

Instructional Procedures

The student taking instruction in the system generally follows a three-step sequence: 1) he views one of the eight demonstration films, 2) he works through a corresponding unit of programed material and 3) he practices the aspects of welding which were depicted in the film and programed text. Student self-evaluation is accomplished by means of end-of-unit reviews and performance checklists.

The Films

The eight demonstration films are color films with sound. They are in continuous loops and are enclosed in plastic cartridges for use in the Fairchild Mark IV projector. The student can view each film as often as he desires without rewinding.

The Books

The programed instruction is contained in two books. Each book is divided into four units; each unit corresponds with one of the demonstration films.

The book units are structured so that each fact which is presented is followed by an incomplete sentence relating to the fact. The student is directed to complete each sentence by responding in the space provided. Correct answers are shown on the back of each page for immediate feedback. A review in the form of a test is provided at the end of each unit. If the student encounters difficulty while completing a test, he is directed to review the films and the appropriate parts of the instruction book. When he can answer all test items correctly, he proceeds as directed to the practice sessions.

The Practice Sessions

The purpose of the practice sessions is to provide the student with the opportunity for application of knowledge and development of skills taught in the films and programed instruction books. In each session, the student is directed through a prescribed set of practice activities by means of a checklist. A significant feature of each practice session is the requirement that each student compares his welds with the model welds which have been provided.

STUDIES OF THE SYSTEM

Sergeant Study

The original developmental work on the self-instructional welding system was done at Washington State University by Harold A. Sergeant. Sergeant summarized his study of the system in the project report. *

The Sergeant study centered about the performance of fifteen high school industrial art students, ten college students and ten non-college adults who worked through the welding system. A performance pretest ensured that the participants initially possessed few or no electric arc welding skills.

All participants reached levels of performance which had been predefined as satisfactory by a jury of welding experts. There was considerable variation in the amount of time required to complete the materials with the college and adult groups requiring less time than the high school group.

These findings suggest that high school students using the electric arc welding system can acquire elementary knowledge and skills in arc welding.

*Sergeant, Harold A. Development and Testing of an Experimental Polysensory Instructional System for Teaching Electric Arc Welding Processes. Final Report No. 24. Olympia: Washington State Coordinating Council for Occupational Education and Pullman: Department of Education, Washington State University, 1968. (ERIC DOC ED 022 957).

Northwest Regional Educational Laboratory Field Test Data

Achievement Data

The welding system was available during the academic years 1968-69 and 1969-70 to students at eight rural high school test sites located throughout Oregon, Washington, Alaska, Montana and Idaho.

For purposes of the present study, two of the sites were used for intensive performance testing. Fourteen students at those sites were subjected to close observation while performing a series of welding tasks. The welding tasks generally coincided with the objectives of the system.

All of the students participating in the present study were male high school students in the ninth through twelfth grade who had recently completed the system. None of the students knew how to weld prior to working with the system. Selection of students to participate in the present study was effected in a quasi-random fashion by the instructors who were told to select "the ten or twelve students who had most recently completed the system."

Teachers at both sites reported that they used the system as a self-instructional device, i.e., after initial observation by the teacher to ascertain that students were adhering to system procedures, the students proceeded independently.

The objectives of the system have two general foci: 1) procedural and equipment safety and 2) six basic welds. An observational checklist was employed to evaluate the objectives which relate to safety.* A rating procedure was employed to evaluate student ability to perform six basic welds. The procedure required the instructor to compare the student welds with model welds which had been provided as part of the system. The model welds were created by professional welders and were intended to illustrate both the good and bad aspects of completed welds. In order to provide reference points for the ratings, the instructors were given specific examples of good and poor features of the various welds. The rating scales are presented in Appendix B.

Findings

Table 1: The instructional objectives relating primarily to safety are listed in capital letters. Each objective is followed by the rating scale used to evaluate student performance. The corresponding percent of students rated in the various categories is also presented.

Six of the twelve objectives presented in Table I were attained by 100 percent of the students. Three objectives were attained by 92 percent, one was attained by 85 percent and two were attained by at least 71 percent. Thus, 83 percent of the safety objectives were attained by at least 85 percent of the students.

*The checklist can be found in the data presentation section as well as in Appendix A, Part II.

TABLE 1.--SUMMARY OF STUDENT PERFORMANCE ON SAFETY RELATED INSTRUCTIONAL OBJECTIVES
(N=14)

		Percent
1a	WEARS APPROPRIATE CLOTHING WHILE WELDING	
	Puts on head shield, apron, jacket, gloves	71 %
	Puts on head shield, apron, gloves	7
	Puts on head shield, jacket, gloves	14
	Puts on head shield, gloves	7
	Puts on head shield only	0
	Fails to put on head shield	0
	TOTAL	99 %
1b	ADJUSTS THE WELDING MACHINE FOR 125 AMPERES	
	Adjusts welder within range of 100-125 amps.	92 %
	Fails to adjust welder	7
	TOTAL	99 %
1c and 1d	IDENTIFIES THE BARE END OF THE WELDING ELECTRODE AND PLACES THE BARE END OF THE WELDING ELECTRODE IN THE GROOVE OF THE JAWS OF THE ELECTRODE HOLDER IN APPROPRIATE POSITION FOR A FLAT WELD	
	Clamps bare end of electrode in appropriate grooves of electrode holder for flat welding	92 %
	Clamps bare end of electrode but NOT in grooves of electrode holder	7
	Fails to clamp bare end of electrode	0
	TOTAL	99 %

TABLE 1.--SUMMARY OF STUDENT PERFORMANCE ON SAFETY RELATED INSTRUCTIONAL OBJECTIVES (Continued)
(N=14)

		Percent
1e	CLAMPS METAL SECURELY BEFORE WELDING	
	Clamps metal securely to the welding table	71 %
	Strikes an arc without clamping practice metal to the table	28
	TOTAL	99 %
2a	POSITIONS PROPERLY THE ELECTRODE AND ELECTRODE HOLDER BEFORE TURNING MACHINE ON	
	Clamps electrode and electrode holder clear of welding table when the machine is turned on	100 %
	Tries to turn machine on with electrode on electrode holder in contact with welding table	0
	TOTAL	100 %
2b	TURNS THE WELDING MACHINE ON WITHOUT ARC FLASH OCCURRING	
	Turns machine on when ready to strike arc	100 %
	Turns machine on without proper safety caution (arc flash occurs)	0
	TOTAL	100 %

TABLE 1.--SUMMARY OF STUDENT PERFORMANCE ON SAFETY RELATED INSTRUCTIONAL OBJECTIVES (Continued)
(N=14)

		Percent
2c and 2d	PREPOSITIONS THE ELECTRODE PROPERLY AFTER MACHINE HAS BEEN TURNED ON and SHIELDS EYES BEFORE STRIKING ARC	
	Positions electrode close to base metal prior to striking arc (about 1 inch) with flip lid open and head shield pulled down or Positions electrode close to base metal prior to striking arc (about 1 inch) with flip lid closed and head shield up	100 %
	Fails to cover eyes before contacting base metal with electrode	0
	TOTAL	100 %
2e	STRIKES AN ARC WITH FLUID-SMOOTH SCRATCHING MOVEMENT OF ELECTRODE	
	Closes flip lid and contacts base metal with fluid-smooth scratching movement of electrode	85 %
	Makes rough erratic contact on base metal with electrode	14
	Does not strike arc	0
	TOTAL	99 %
2f	KEEPS WORK AREA SAFE BY DISPOSING OF ELECTRODES PROPERLY	
	Puts used electrode ends in waste can	*100 %
	Puts used electrode ends on floor	0
	TOTAL	100 %

*N=12 (two students not observed)

TABLE 1.--SUMMARY OF STUDENT PERFORMANCE ON SAFETY RELATED INSTRUCTIONAL OBJECTIVES (Continued)
(N=14)

		Percent
2g	TURNS MACHINE OFF AT COMPLETION OF PRACTICE SESSION	
	Turns machine off at end of practice session	*100 %
	TOTAL	100 %
2h	USES A CHIPPING HAMMER AND WIRE BRUSH TO REMOVE THE SLAG FROM THE WELD BEADS AND CLEAN THE METAL SURFACE	
	Removes slag, i.e., cleans bead and metal surface, head shield down, flip lid up	92 %
	Attempts to remove slag with eyes unprotected	7
	TOTAL	99 %
8b	IDENTIFIES CORRECT AND INCORRECT BEADS WHEN PRESENTED WITH EIGHT SAMPLE WELDS, TWO OF WHICH ARE INCORRECT	
	Makes proper discrimination and indicates at least one improper aspect of each of the incorrect welds or Makes proper discrimination between correct and incorrect welds	100 %
	Fails to make proper discrimination between the six correct and two incorrect welds	0
	TOTAL	100 %

*N=13 (one student not observed)

As previously noted, the arc welding system has two foci: 1) safety related objectives and 2) six basic welds. Evaluation of student performance on the six basic welds entailed rating various aspects of each type of weld. Specifically, five welds, i.e., flat, fillet, fillet (weave bead), weave bead and horizontal fillet (multiple pass) were rated on the following aspects:

1. Good penetration
2. Uniformity
3. Adequate Size
4. No undercutting
5. Lack of excessive spatter
6. Lack of excessive piling up of metal or overlap

The sixth welding task, i.e., restarting beads, was rated on only two aspects, namely, "sufficient metal deposit" and "lack of excessive metal deposit when restarting bead."

Student performance on the rated aspect of each welding task has been summarized and the resultant tables have been placed in Appendix B. Following are the general indications from the summary of ratings.

Flat weld: all but one student on one aspect, i.e., "good penetration" was rated better than the incorrect model. At least 21 percent performed at or better than the "correct" professional model level on the remaining aspects with at least 7 percent rated above the "correct" professional model level.

Fillet weld: all but two students on two aspects, i.e., "uniformity" and "adequate size" were rated above the "incorrect" model level. None were rated below the "incorrect" model level. On five of six aspects at least 21 percent of the students were rated at or above the "correct" professional model level.

Fillet weld (weave bead): on two of six aspects, i.e., "adequate size" and "lack of excessive metal build up" only one student was rated as low as the level of the "incorrect" model. On five of six aspects at least 28 percent of the students were rated at or above the"correct" professional model level.

Weave bead weld: only one student on one aspect, i.e., lack of "excessive piling up" was rated as low as the "incorrect" model level. On five of six aspects at least 28 percent of the students performed at or better than the "correct" professional model level.

Multiple pass horizontal fillet weld: all students on all aspects were rated above the "incorrect" model level. At least 35 percent of the students performed at or above the "correct" professional model level.

Restarting beads: no student was rated as low as the "incorrect" model level. For the "sufficient metal deposit" aspect, 50 percent were rated at or above the "correct" professional model level. For the second aspect, i.e., "lack of excessive metal deposit," 14 percent of the students attained the "correct" professional model level.

All six welds: all students were able to perform all six welds. Thus, student performance was never rated lower than the "incorrect" professional model level. In each instance of minimal performance, the performance of the majority of students was rated considerably higher, with a minimum of 14 percent of the students rated at or above the level of the "correct" professional model for each aspect of each weld.

Two general trends are evident from the foregoing data:

1. The median ratings attained by the students for each aspect of all six welds were above the midpoint between the "incorrect" and "correct" professional model levels

2. The self-instructional system in arc welding taught rural high school students who had no previous arc welding experience how to perform six basic welds.

Affective Data

During the spring of 1969, an opinion survey was conducted among students and teachers using the welding system at the eight rural high school test sites. Students were polled about their attitudes toward the system. One question asked was, "Would you recommend this sytem to your friends?" Seventy-five of the 84 respondents, or 90.4 percent, replied in the affirmative.

Another question asked was, "Would you be interested in taking another course using a system like this one?" Fifty of the 51 respondents, or 98 percent, replied in the affirmative. These data would seem to indicate positive student acceptance of the system.

The teacher/managers of the welding system were asked to respond to an opinion questionnaire at the same time student attitudes were polled.

One question asked was, "Would you recommend this system to other teachers?" All seven respondents answered in the affirmative. This finding would seem to indicate positive teacher acceptance of the system.

Summary

Achievement data available from the Sergeant study and the Northwest Regional Educational Laboratory's rural test sites indicate that students are able to perform a variety of welding tasks after using the self-instructional system in electric arc welding. Additionally, 83 percent of the safety-oriented objectives were attained by at least 85 percent of the students. Attitudes of students and teachers toward the system were found to be quite positive.

EDUCATIONAL SPECIFICATIONS OF THE SYSTEM

Systems focus:	Introductory material in arc welding at senior high school level
Instructional mode:	Self-instructional with provisions for practice in use of electric arc welding equipment
Student performance:	Measured by observational guides and based on 14 rural high school students, 85 percent of the students attained at least 83 percent of the system objectives relating to safety and procedures. All of the students in the sample were able to perform six basic welding tasks with at least 21 percent of the student performances rated at or above the level of the "correct" professional model welds.

HISTORY OF THE SYSTEM

Dr. Gordon McCloskey of Washington State University (Pullman) initiated a Vocational-Technical Education Research and Development Project in 1966. The project identified and defined clusters of capabilities essential for occupations often chosen by youth who do not complete college. Also identified were the psychological, sociological and economic factors that influenced students to seek educational programs for training in skills essential for employment. The information from the project supplied the basis for the design of prototpye vocational instructional materials.

The Elementary and Secondary Education Act of 1965 gave further impetus to the Vocational Project with funds available under Title III and the involvement of the Northwest Regional Educational Laboratory, established under Title IV. Cooperative efforts resulted in the identification, development and field testing of vocational instructional systems for plastics, speech, welding, Spanish, mathematics analysis, physical science and electricity.

Personnel directly involved in the welding project include:

Washington State University: Gordon McCloskey, Arnold Gallegos, Harold Sergeant, Frank Nelson, Gerald Brunner and Dennis Gillis.

Northwest Regional Educational Laboratory: Roger Bishop, Chester Hausken, Walter Hartenberger, Ray Jongeward, Mark Greene, Joan Goforth, Al Selinger, Mary Ganzel and Gail Murray.

APPENDIX A

ACHIEVEMENT TEST FOR ARC WELDING SYSTEM

Part I: Directions for Administering the Test

Part II: Performance Checklist

Part III: Instructions for Rating Student Welds

APPENDIX A: ACHIEVEMENT TEST FOR ARC WELDING SYSTEM

Part I: Directions for Administering the Test

The purpose of the present study is to determine the extent to which the welding system teaches students to weld. In order to make such a determination, we would like you to select the ten or twelve students in your classes who have been through the system most recently. We would then like to have you observe them as they perform a series of welding tasks. A checklist has been provided so that you can make the necessary observations. It is very important that complete observations be made and recorded for each student. *

Procedure

Ask the student to prepare for welding. (The specific way of stating this request is found on the next page.) As he makes his preparations, you are to rate and record his actions on the attached checklist.

Using a prefabricated T-joint, ask the student to make a flat weld, a fillet weld, a fillet weld (weave bead), a flat weave bead and a multiple pass horizontal fillet. (See Diagram I) While the student is doing his flat bead, have him stop and restart the bead. In determining the extent of penetration, have the student stop the weld an inch from the edge of the metal.

* A list of the equipment and materials which you will need for the study can be found on page 22.

When the student is in the shop, say"

"This is an experiment in the use of teaching materials that help pupils learn. You can help your instructor find more interesting and effective ways of teaching. Your work on this project will be helpful to many other students."

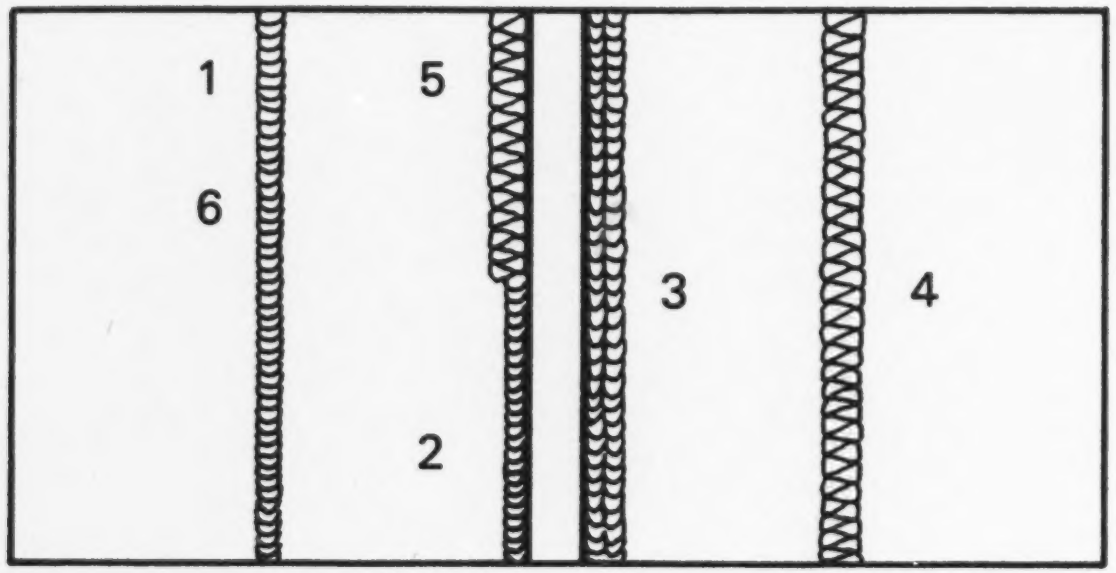
Ask the student to join you at the practice area where equipment and materials are located. Show the student a flat weld. Say:

"The material and equipment necessary to weld are here. The first part of this project is to prepare the welding equipment and materials for welding. Please show me how you run a flat horizontal bead."

Equipment and Materials

The following equipment and materials should be made available in the practice area:

- 250 Arc Welder Lincoln A. C.
- Welding leads
- Ball peen hammer
- Ground clamp
- Hacksaw
- Electrode holder
- Ten-twelve prefabricated T-joints 3/16" x 3" x 5"
- Chipping hammer
- Cold chisel
- Wire brush
- Five gallon water bucket (3/4 full of water)
- Bench brush
- Eight sample welds including two correct models and six incorrect models
- Stand to position steel for fillet weld
- Seven display boards
- Metal clamp
- Welding head shield with safety flip lid
- Welding gloves
- Welding apron
- Welding jacket
- Welding practice table
- Supply of welding electrodes 1/8" E 6013
- Example beads (mounted)
- Pliers
- Jig for breaking welds (if available)
- Performance checklist



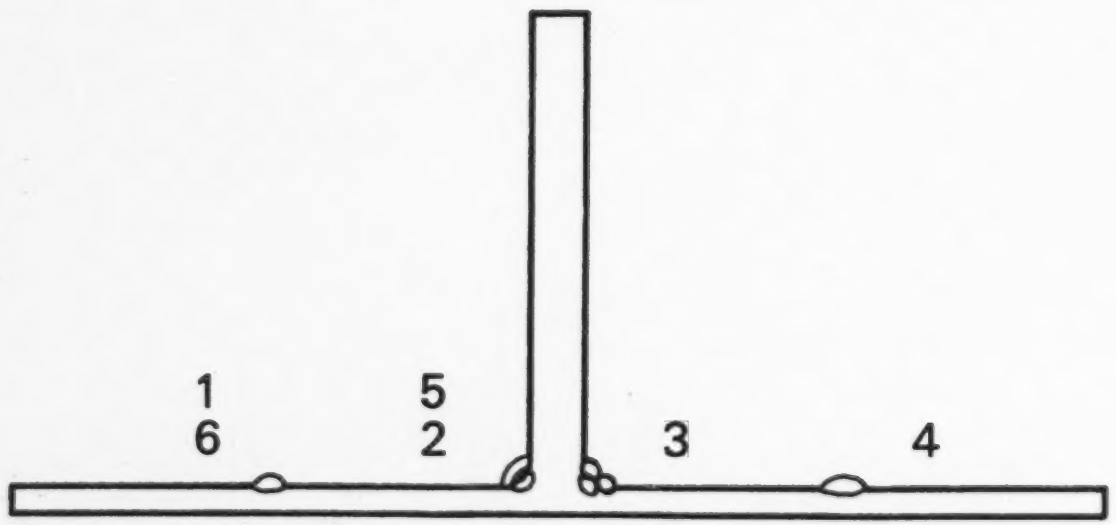


Diagram I. Schematic of preformed T-joint indicating location of welds to be performed.

KEY

1. Flat bead
2. Fillet weld
3. Multiple pass
4. Flat weave
5. Fillet weave
6. Restart bead

APPENDIX A: ACHIEVEMENT TEST FOR ARC WELDING SYSTEM

Part II: Performance Checklist

Student's Name _____ Time Started _____

School _____ Time Finished _____

Date _____

PERFORMANCE CHECKLIST

Instructional Objectives	Measurements
	Tested by means of performance checklist
1. Equipment and Safety	1. a.
a. To wear appropriate clothing while welding	____(3) Puts on head shield, apron, jacket, gloves ____(2) Puts on head shield, apron, gloves ____(2) Puts on head shield, jacket, gloves ____(1) Puts on head shield, gloves ____(0) Puts on head shield only ____(0) Fails to put on head shield
1. b. To adjust the welding machine for 125 amperes	1. b. ____(3) Adjusts welder within range of 100-125 amps ____(0) Fails to adjust welder
1. c. To identify the bare end of the welding electrode	1. c. and d. ____(3) Clamps bare end of electrode in appropriate grooves of electrode holder for flat welding
1. d. To place the bare end of the welding electrode in the groove of the jaws of the electrode holder in appropriate position for a flat weld	____(2) Clamps bare end of electrode but NOT in grooves of electrode holder ____(0) Fails to clamp bare end of electrode
1. e. Clamps metal securely before welding	1. e. ____(3) Clamps metal securely to the welding table ____(0) Strikes an arc without clamping practice metal to the table

Instructional Objectives Welding and Safety		Measurements Checklist (continued)	
2. a.	To position properly the electrode and electrode holder before turning machine on	2. a. ____(3)	The clamped electrode and electrode holder is clear of welding table when the machine is turned on
		____(0)	Student tries to turn machine on with electrode on electrode holder in contact with welding table
2. b.	To turn the welding machine ON without arc flash occurring	2. b. ____(3)	Turns machine on when ready to strike arc
		____(1)	Turns machine on without proper safety caution (arc flash occurs)
		____(0)	Fails to turn machine on
2. c.	To preposition the electrode properly after machine has been turned on	2. c. & d. ____(3)	Positions electrode close to base metal prior to striking arc (about 1 inch) with flip lid open and head shield pulled down
2. d.	To shield eyes before striking arc	____(2)	Positions electrode close to base metal prior to striking arc (about 1 inch) with flip lid closed and head shield up
		____(0)	Fails to cover eyes before contacting base metal with electrode
2. e.	To "strike an arc" with fluid-smooth scratching movement of electrode	2. e. ____(3)	Closes flip lid and contacts base metal with fluid-smooth scratching movement of electrode
		____(1)	Makes rough erratic contact on base metal with electrode
		____(0)	Does not "strike arc"
2. f.	To keep work area safe by disposing of electrodes properly	2. f. ____(3)	Puts used electrode ends in fireproof container
		____(0)	Puts used electrode ends on floor
2. g.	To turn machine off at completion of practice session	2. g. ____(3)	Turns machine off at end of practice session
2. h.	To use a chipping hammer and wire brush to remove the slag from the weld beads and clean the metal surface	2. h. ____(3)	Removes slag (cleans bead and metal surface), head shield down, flip lid up
		____(0)	Attempts to remove slag with eyes unprotected
		____(0)	Fails to attempt removal of slag

Part III: Instructions for Rating Student Welds

Flat Weld Evaluation

Your task is to compare various aspects of the student's welds with the "correct" and "incorrect" model welds on the display board. A comparison model will be designated for each quality named. Please rate the student welds in accordance with the following scheme:

For the quality named, the student weld is:

1. Worse than the "incorrect" model.
2. About the same as the "incorrect" model.
3. Somewhat better than the "incorrect" model.
4. About midway between the "correct" and the "incorrect" model.
5. Somewhat worse than the "correct" model.
6. About the same as the "correct" model.
7. Better than the "correct" model.

Quality or aspect of Student Weld to be Rated	Comparison Board Title	Sample Title	Instructor Rating (circle appropriate number)
1. Good penetration	a. "Weld beads"	"Moving electrode too fast" "Arc length too long" "Varied arc length"	1 2 3 4 5 6 7
2. No undercutting	b. "Horizontal beads"	"Undercutting"	1 2 3 4 5 6 7
3. Lack of excessive spatter	c. "Horizontal beads" "Weld beads"	"Arc length too long" "Varied arc length"	1 2 3 4 5 6 7
4. Uniformity	d. "Weld beads" "Horizontal beads"	"Varied arc length" "Arc length too long" "Thin irregular bead"	1 2 3 4 5 6 7
5. Adequate size	e. "Weld beads" "Horizontal beads"	"Varied arc length" "Moving electrode too fast" "Thin irregular bead"	1 2 3 4 5 6 7
6. Lack of excessive piling up of metal or overlap	f. "Weld beads"	"Moving electrode too slow"	1 2 3 4 5 6 7

Fillet Weld Evaluation

Your task is to compare various aspects of the student's welds with the "correct" and "incorrect" model welds on the display board. A comparison model will be designated for each quality named. Please rate the student welds in accordance with the following scheme:

For the quality named, the student weld is:

1. Worse than the "incorrect" model.
2. About the same as the "incorrect" model.
3. Somewhat better than the "incorrect" model.
4. About midway between the "correct" and the "incorrect" model.
5. Somewhat worse than the "correct" model.
6. About the same as the "correct" model.
7. Better than the "correct" model.

Quality or aspect of Student Weld to be Rated	Comparison Board Title	Sample Title	Instructor Rating (circle appropriate number)
1. Good penetration	a. "Fillet weld"	"Moving electrode too slow"	1 2 3 4 5 6 7
2. No undercutting	b. "Fillet weld"	"Moving electrode too slow"	1 2 3 4 5 6 7
3. Lack of excessive spatter	c. "Horizontal beads"	"Arc length too long"	1 2 3 4 5 6 7
4. Uniformity	d. "Fillet weld"	"Uneven arc distribution" "Arc length too long"	1 2 3 4 5 6 7
5. Adequate size	e. "Fillet weld"	"Moving electrode too fast"	1 2 3 4 5 6 7
6. Lack of excessive piling up of metal or overlap	f. "Fillet weld"	"Moving electrode too slow"	1 2 3 4 5 6 7

Fillet Weld (Weave Bead) Evaluation

Your task is to compare various aspects of the student's welds with the "correct" and "incorrect" model welds on the display board. A comparison model will be designated for each quality named. Please rate the student welds in accordance with the following scheme:

For the quality named, the student weld is:

1. Worse than the "incorrect" model.
2. About the same as the "incorrect" model.
3. Somewhat better than the "incorrect" model.
4. About midway between the "correct" and the "incorrect" model.
5. Somewhat worse than the "correct" model.
6. About the same as the "correct" model.
7. Better than the "correct" model.

Quality or aspect of Student Weld to be Rated		Comparison Board Title	Sample Title	Instructor Rating (circle appropriate number)
1.	Good penetration	a. "Fillet weld (weave bead)"	"High contour in center of bead"	1 2 3 4 5 6 7
2.	No undercutting	b. "Fillet weld (weave bead)"	"Undercutting along edges"	1 2 3 4 5 6 7
3.	Lack of excessive spatter	c. "Fillet weld (weave bead)"	"Excessive spatter"	1 2 3 4 5 6 7
4.	Uniformity	d. "Fillet weld (weave bead)"	"Undercutting along edges"	1 2 3 4 5 6 7
5.	Adequate size	e. "Fillet weld (weave bead)"	"Insufficient metal deposit"	1 2 3 4 5 6 7
6.	Lack of excessive piling up of metal or overlap	f. "Fillet weld (weave bead)"	"High contour in center of bead"	1 2 3 4 5 6 7

Weave Bead Evaluation

Your task is to compare various aspects of the student's welds with the "correct" and "incorrect" model welds on the display board. A comparison model will be designated for each quality named. Please rate the student welds in accordance with the following scheme:

For the quality named, the student weld is:

1. Worse than the "incorrect" model.
2. About the same as the "incorrect" model.
3. Somewhat better than the "incorrect" model.
4. About midway between the "correct" and the "incorrect" model.
5. Somewhat worse than the "correct" model.
6. About the same as the "correct" model.
7. Better than the "correct" model.

Quality or aspect of Student Weld to be Rated		Comparison Board Title		Sample Title	Instructor Rating (circle appropriate number)
1.	Good penetration	a.	"Weave beads"	"Overlapping"	1 2 3 4 5 6 7
2.	No undercutting	b.	"Horizontal beads"	"Undercutting"	1 2 3 4 5 6 7
3.	Lack of excessive spatter	c.	"Weave bead"	"Improper bead formation"	1 2 3 4 5 6 7
4.	Uniformity	d.	"Weave bead"	"Improper bead formation" "Bead thin and irregular"	1 2 3 4 5 6 7
5.	Adequate size	e.	"Weave bead"	"Improper bead formation" "Bead thin and irregular"	1 2 3 4 5 6 7
6.	Lack of excessive piling up of metal or overlap	f.	"Weave bead"	"Overlapping" "High contour in center of bead"	1 2 3 4 5 6 7

Horizontal Fillet (Multiple Pass) Evaluation

Your task is to compare various aspects of the student's welds with the "correct" and "incorrect" model welds on the display board. A comparison model will be designated for each quality named. Please rate the student welds in accordance with the following scheme:

For the quality named, the student weld is:

1. Worse than the "incorrect" model.
2. About the same as the "incorrect" model.
3. Somewhat better than the "incorrect" model.
4. About midway between the "correct" and the "incorrect" model.
5. Somewhat worse than the "correct" model.
6. About the same as the "correct" model.
7. Better than the "correct" model.

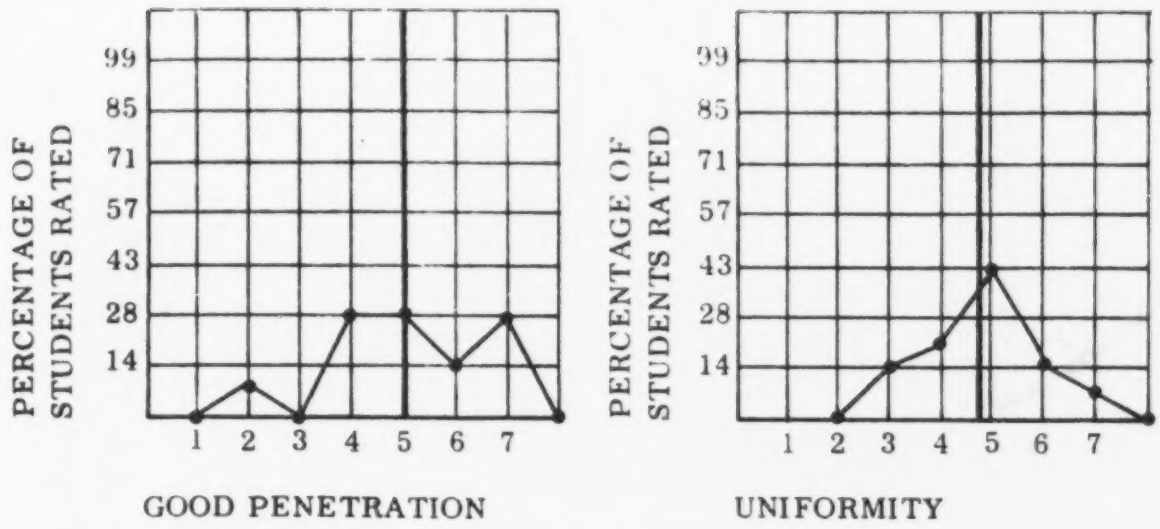
Quality or aspect of Student Weld to be Rated		Comparison Board Title	Sample Title	Instructor Rating (circle appropriate number)
1.	Good penetration	a. "Fillet weld weave bead"	"High contour in center of bead"	1 2 3 4 5 6 7
2.	No undercutting	b. "Horizontal fillet weld"	"Undercutting along edge"	1 2 3 4 5 6 7
3.	Lack of excessive spatter	c. "Horizontal fillet weld"	"Insufficient metal deposit"	1 2 3 4 5 6 7
4.	Uniformity	d. "Horizontal fillet weld"	"Irregular bead deposit"	1 2 3 4 5 6 7
5.	Adequate size	e. "Horizontal fillet weld"	"Insufficient metal deposit"	1 2 3 4 5 6 7
6.	Lack of excessive piling up of metal or overlap	f. "Weld bead"	"Moving electrode too slow"	1 2 3 4 5 6 7

Quality or Aspect of Student Weld to be Rated	Comparison Board Title	Sample Title	Instructor Rating
A. Restarting Beads			
1. Sufficient metal deposit	a. "Restarting beads"	"Insufficient metal deposit"	1 2 3 4 5 6 7
2. Lack of excessive metal deposit when restarting bead	b. "Restarting beads"	"Excessive metal deposit when restarting beads"	1 2 3 4 5 6 7

	Instructional Objectives	Measurements
8.	B. To identify correct and incorrect beads.	Presented with eight sample welds, two of which are incorrect, student: ____(3) Makes proper discrimination and indicates at least one improper aspect of each of the incorrect welds ____(3) Makes proper discrimination between correct and incorrect welds ____(0) Fails to make proper discrimination between the two correct and six incorrect welds

APPENDIX B

STUDENT-RATED PERFORMANCE ON EACH ASPECT OF SIX WELDING TASKS

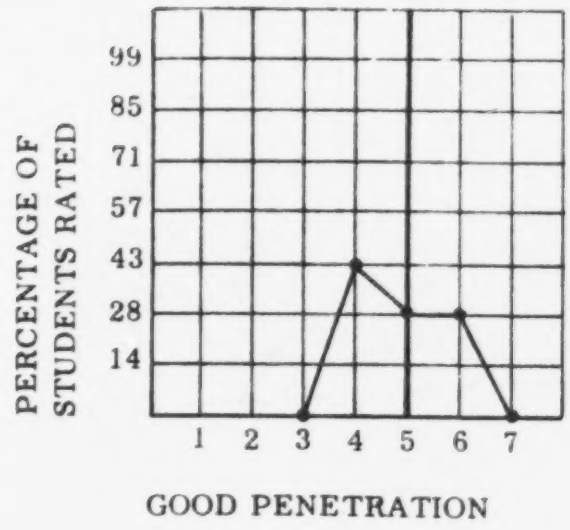


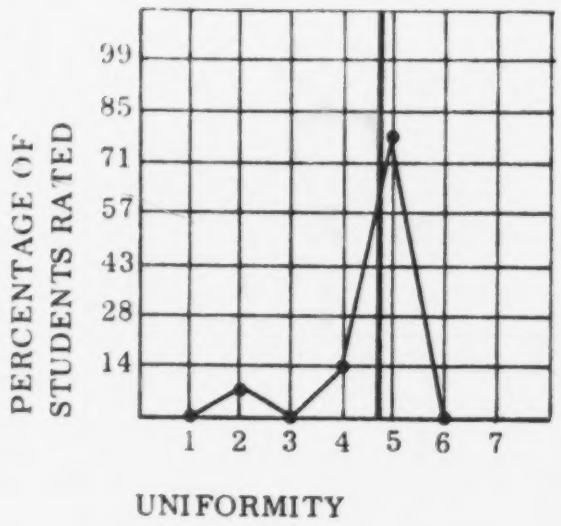
KEY TO RATINGS

For the quality named, the student weld is:

1. Worse than the "incorrect" model
2. About the same as the "incorrect" model
3. Somewhat better than the "incorrect" model
4. About midway between the "correct" and the "incorrect" model
5. Somewhat worse than the "correct" model
6. About the same as the "correct" model
7. Better than the "correct" model

Fig. 1. Student-rated performance on six aspects of the flat weld.

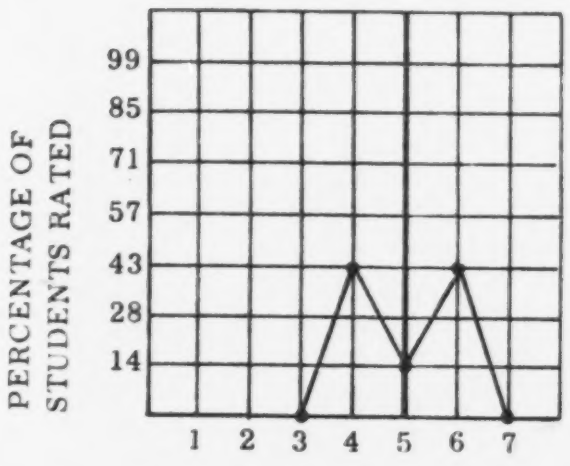


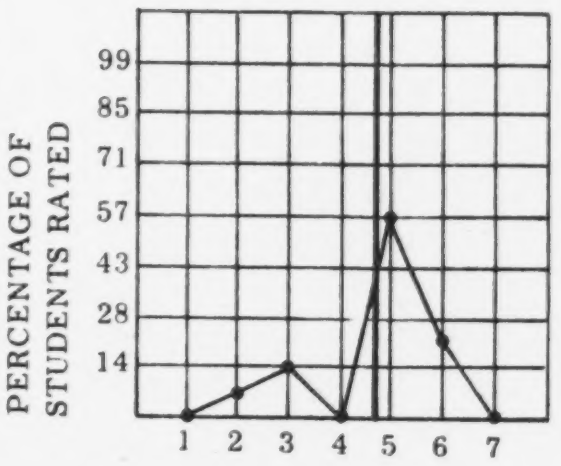


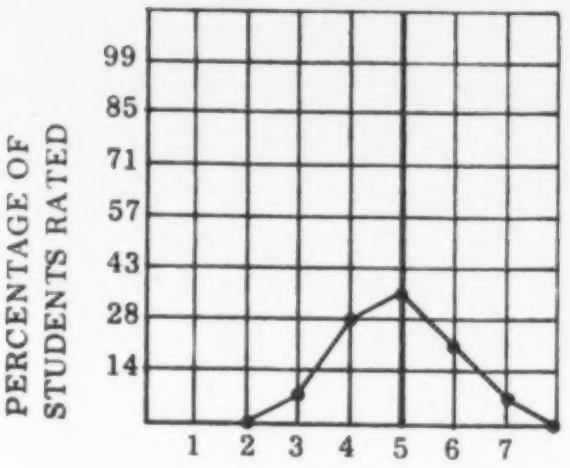
KEY TO RATINGS

For the quality named, the student weld is:

1. Worse than the "incorrect" model
2. About the same as the "incorrect" model
3. Somewhat better than the "incorrect" model
4. About midway between the "correct" and the "incorrect" model
5. Somewhat worse than the "correct" model
6. About the same as the "correct" model
7. Better than the "correct" model







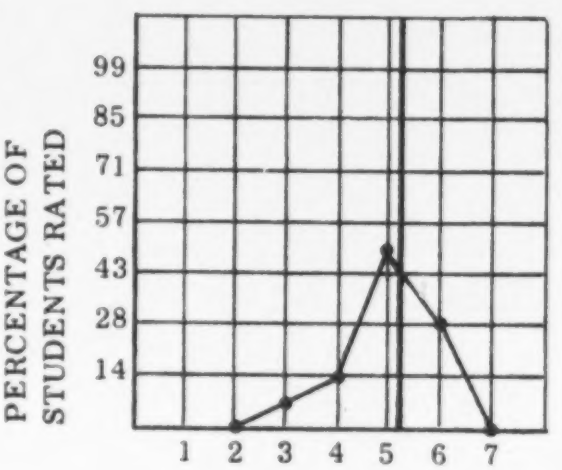
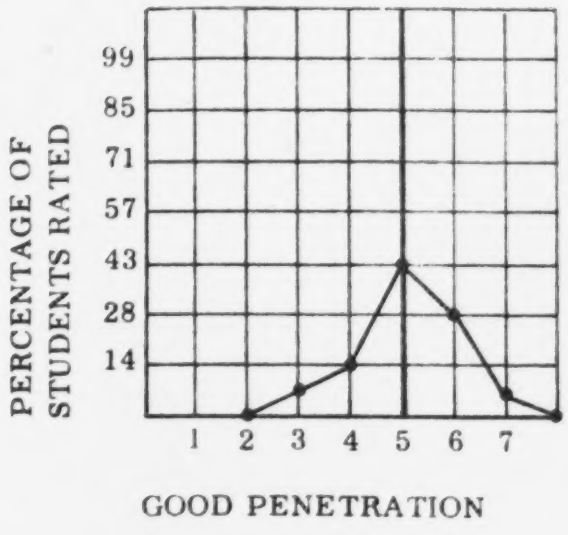
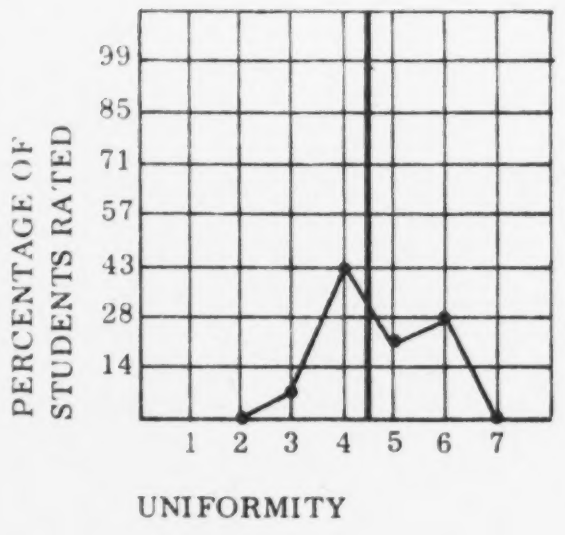


Fig. 2. Student-rated performance on six aspects of the fillet weld.

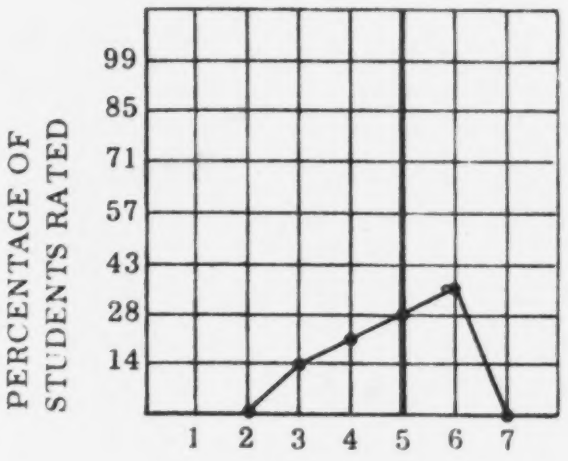


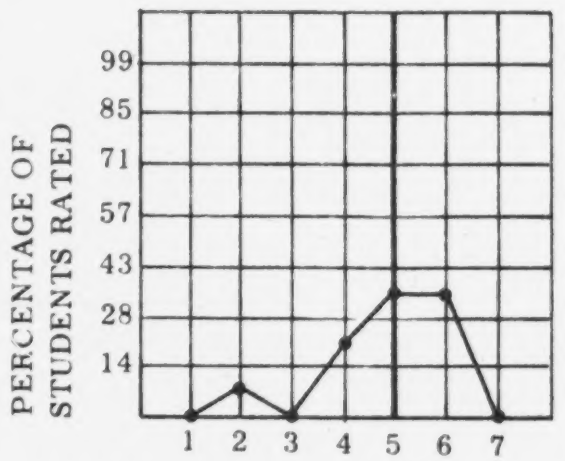


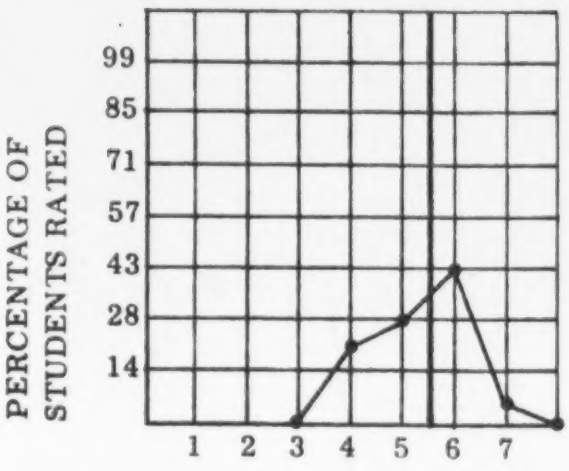
KEY TO RATINGS

For the quality named, the student weld is:

1. Worse than the "incorrect" model
2. About the same as the "incorrect" model
3. Somewhat better than the "incorrect" model
4. About midway between the "correct" and the "incorrect" model
5. Somewhat worse than the "correct" model
6. About the same as the "correct" model
7. Better than the "correct" model







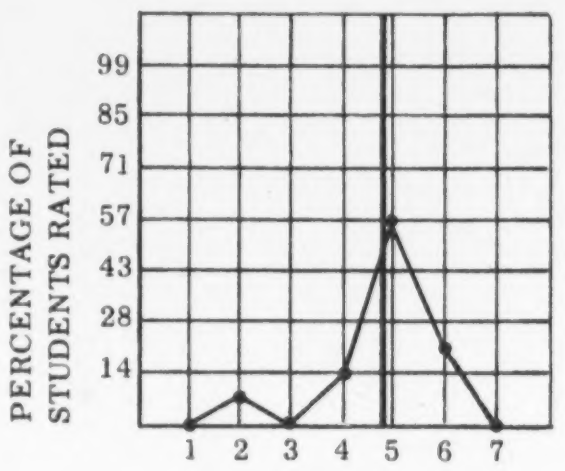
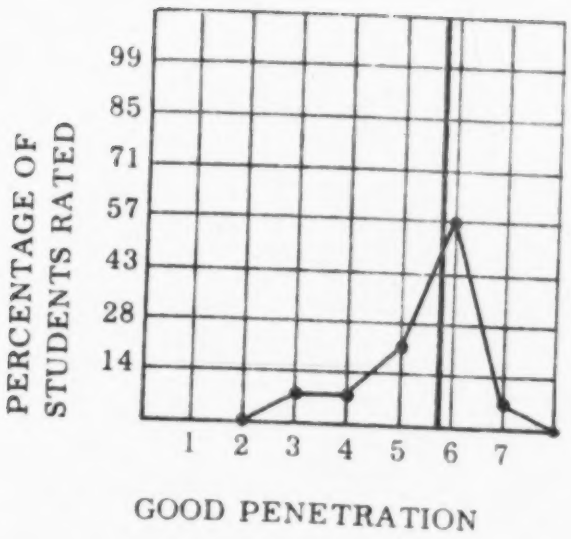
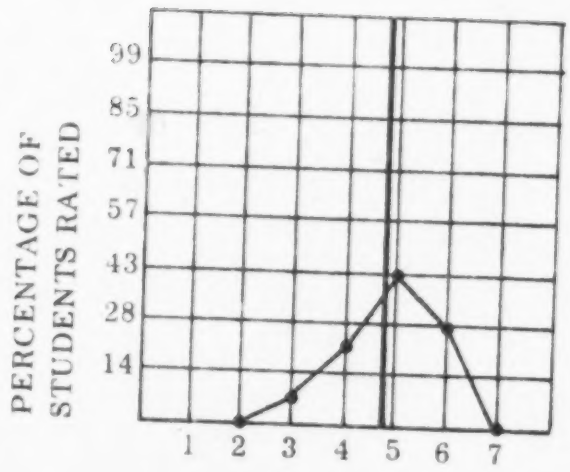


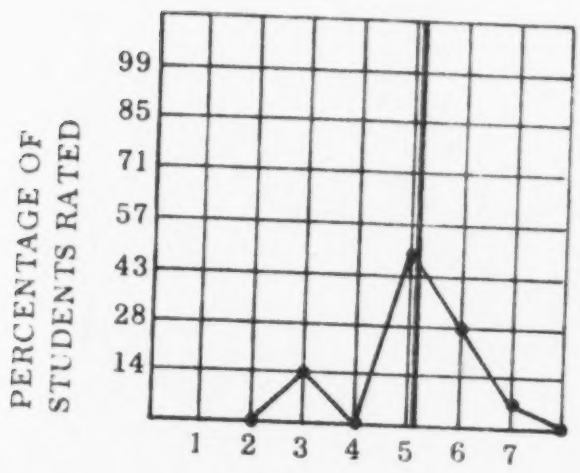
Fig. 3. Student-rated performance on six aspects of the fillet weld (weave bead).



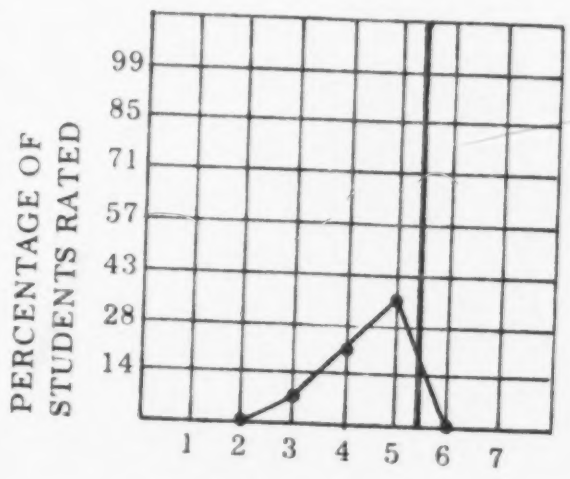
GOOD PENETRATION



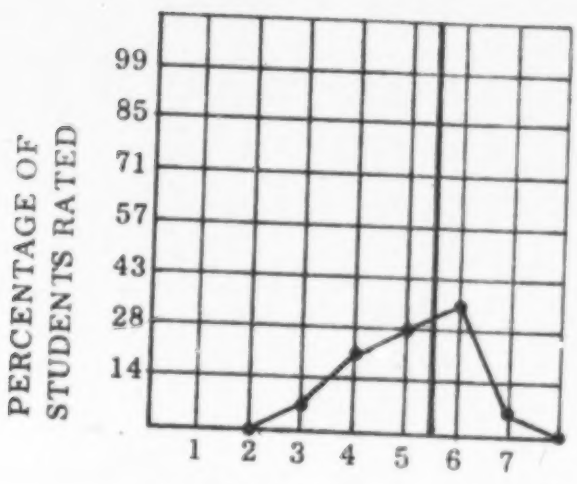
UNIFORMITY



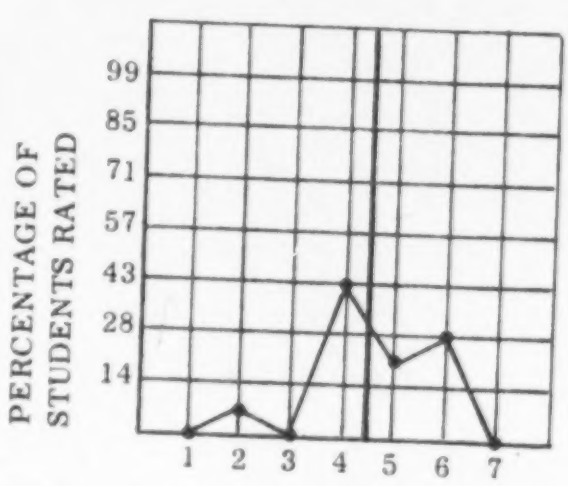
NO UNDERCUTTING



ADEQUATE SIZE



LACK OF EXCESSIVE SPATTER



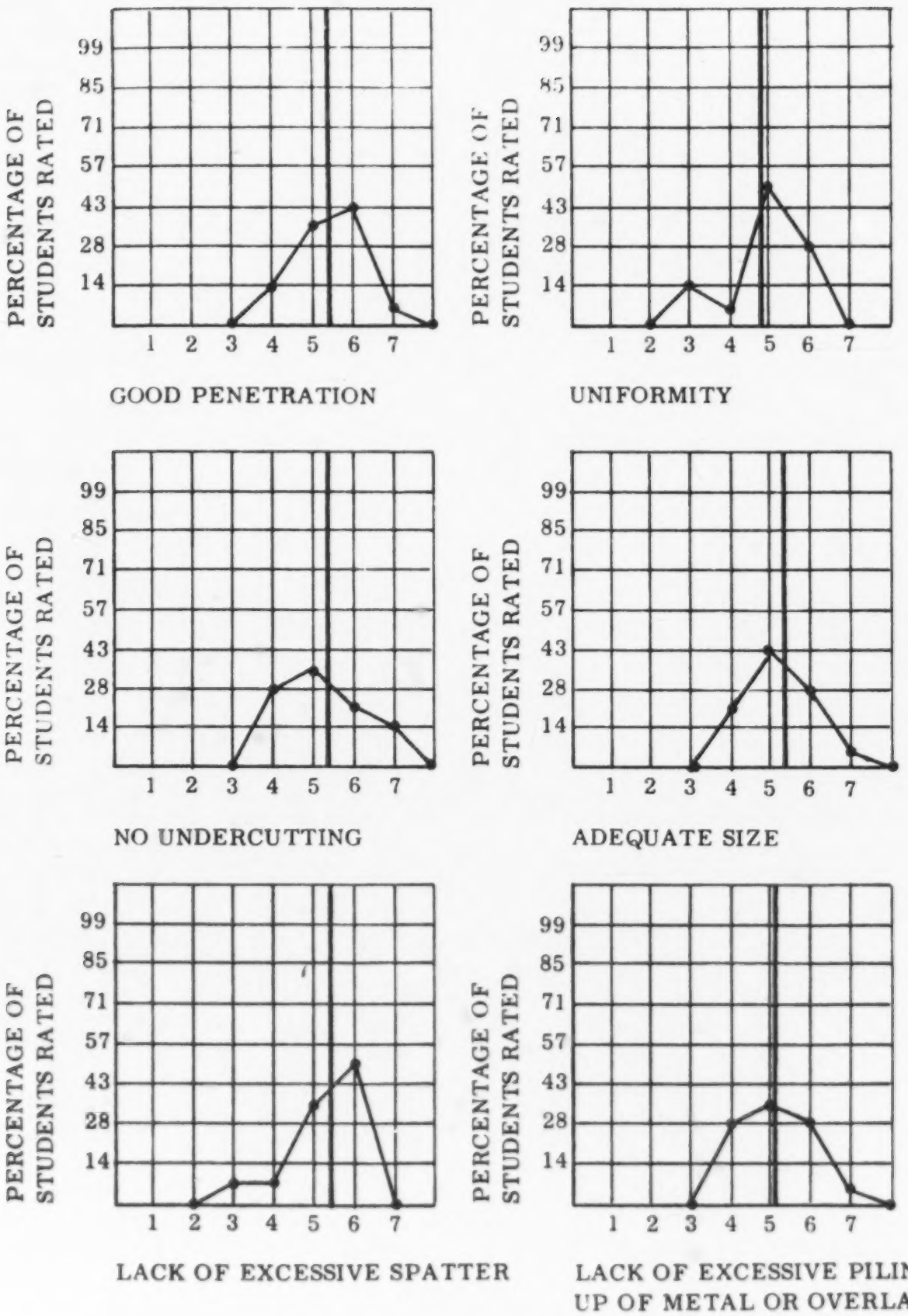
LACK OF EXCESSIVE PILING UP OF METAL OR OVERLAP

KEY TO RATINGS

For the quality named, the student weld is:

1. Worse than the "incorrect" model
2. About the same as the "incorrect" model
3. Somewhat better than the "incorrect" model
4. About midway between the "correct" and the "incorrect" model
5. Somewhat worse than the "correct" model
6. About the same as the "correct" model
7. Better than the "correct" model

Fig. 4. Student-rated performance on six aspects of the weave bead weld.

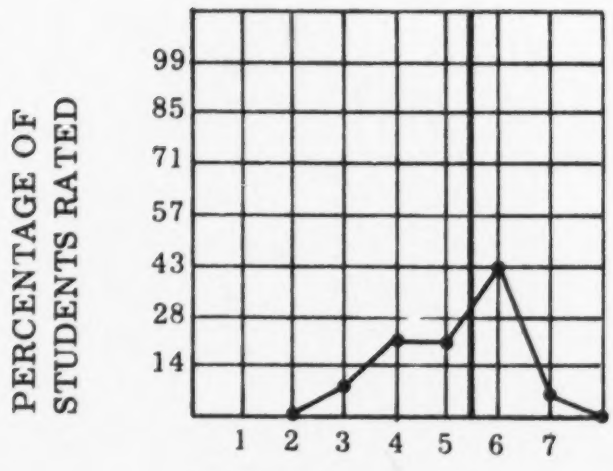


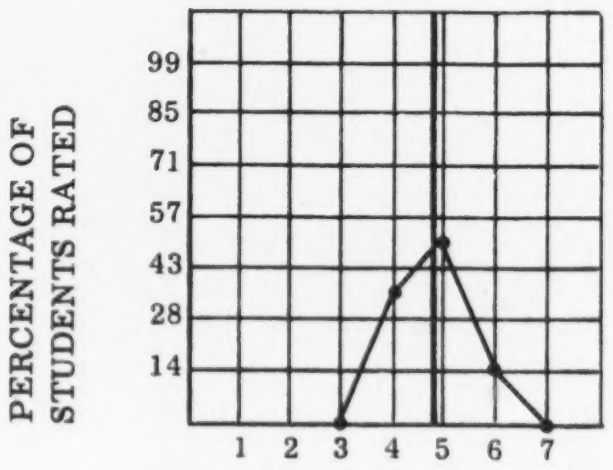
KEY TO RATINGS

For the quality named, the student weld is:

1. Worse than the "incorrect" model
2. About the same as the "incorrect" model
3. Somewhat better than the "incorrect" model
4. About midway between the "correct" and the "incorrect" model
5. Somewhat worse than the "correct" model
6. About the same as the "correct" model
7. Better than the "correct" model

Fig. 5. Student-rated performance on six aspects of the horizontal fillet (multiple pass) weld.





KEY TO RATINGS

For the quality named, the student weld is:

1. Worse than the "incorrect" model
2. About the same as the "incorrect" model
3. Somewhat better than the "incorrect" model
4. About midway between the "correct" and the "incorrect" model
5. Somewhat worse than the "correct" model
6. About the same as the "correct" model
7. Better than the "correct" model

Fig. 6. Student-rated performance on two aspects of restarting welding beads.